TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 79
SEPTEMBER, 1916

IMPOUNDED WATER

SURVEYS IN ALABAMA AND SOUTH CAROLINA DURING 1915 TO DETERMINE ITS EFFECT ON PREVALENCE OF MALARIA

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PREPARED BY DIRECTION OF THE SURGEON GENERAL

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IMPOUNDED WATER.

SURVEYS IN ALABAMA AND SOUTH CAROLINA DURING 1915 TO DETERMINE ITS EFFECT ON PREVALENCE OF MALARIA.

The investigation of the effect of impounded waters on the incidence of malaria, begun in 1914 and reported in the Public Health Reports,[1] was continued during 1915. Surveys were made of the following bodies of water: The pool of Lock 12 on the Coosa River; the pool of Lock 17, Black Warrior River; the pond of the Parr Shoals hydroelectric power plant; and the pond of the Georgia and Carolina hydroelectric power plant at Stevens Creek. The first two are in Alabama and the last two in South Carolina. In addition, a cursory survey, but sufficient for the purpose intended, was made of two ponds of water of the Tennessee Coal, Iron & Railroad Co. near Birmingham, Ala. Incidental to other work a survey was also made of three small ponds in Virginia. Practically this was a physical survey, as it was too late[2] for the biological survey to be satisfactory, though such a survey was carried out so far as practicable.

It had been planned to make surveys of typical areas showing the following conditions:

(1) An area to be covered, but as yet not covered, by a large pond and its environment, the dam to make the pond being in process of construction (or soon to be constructed). Comparison of this survey of the locality in its natural condition, with subsequent surveys after the pond was filled, would give exact data on the change in conditions produced by the pond.

(2) A pond in its first year.

(3) A pond in its second year.

The last two were to be selected in environments as nearly alike as obtainable, and these surveys were intended to determine the change in the pond from the first to the second year, as there was some reason to believe that this change might be considerable. Three suitable units were selected in Alabama.

A physical survey of the ponds at Parr Shoals and Stevens Creek in February, 1915, however, had shown that they presented some

[1] Reprints No. 244, 248, and 257, U. S. Public Health Reports. [2] October.

unusual features and that a biological survey of them was immediately advisable to determine the existing conditions,[1] and especially to enable us to give advice to correct certain insanitary conditions which it seemed very probable would obtain about portions of them. The survey of the area to be covered, but not yet covered, by the impounded water contemplated under (1) was therefore postponed and that of these two ponds taken in its place. This was the more advisable, as, owing to industrial conditions, the site selected for this survey would not be covered by water for at least two years.

SURVEY OF PONDS IN ALABAMA.

In order to examine the pond under different conditions of season, water, etc.,[2] two surveys of the pool of Lock No. 12, Coosa River, were made, May 28 to June 25 and August 18 to September 19. The power plant and Talladega Springs were used as bases to work from in both surveys and a power launch was used to reach the different parts of the pool. The actual work was done on foot or in a canoe.

This pond was in its second season, having been filled in June or July, 1914. It had been the object of quite a thorough survey by Le Prince and Donley during October and November, 1914. In our June, 1915, survey it was examined by "sampling." All creeks and large branches were examined up to and beyond backwater, and portions of the banks of the main pond and of the bayous caused by these affluents were selected in different places and examined thoroughly. Large numbers of sample banks were examined and pains taken to select those that would be apt to breed or shelter *Anopheles* larvæ. Some places were examined more than once at intervals of from four days to a week.

In the survey made in August and September a few localities believed to be fairly typical were examined carefully, and more than once. The survey was an intensive study of such type places, and no attempt was made to examine a great number of places, much less the whole pool, which has a shore line estimated at from 90 to 120 miles. Some examination was also made of territory beyond the influence of the pool. This work was fairly complete, and the state of the pool, as affecting malaria incidence for this year, can be given with a fair degree of accuracy.

The survey of the pool of Lock 17 on the Black Warrior was not attempted on the same scale as was that of the Coosa pool. It would have required the entire summer to do so, and the information gained would have been less than that which the same time spent elsewhere would give. We spent from June 27 to July 17 on this pool and

[1] They were filled in June or July of last year.

[2] See Reprint No. 244 from Public Health Reports, p. 12.

examined three sections of it: (*a*) Using the lock as a base, from the lock up for 6 miles on both sides and in every inlet and up every creek (except one) and branch to the head of backwater and some distance beyond; (*b*) using Maxine and a farm house on Prescott Creek as bases, the whole of the Locust Fork of the Warrior up to Short Creek and its affluent creeks and branches; (*c*) using Cordova as a base, the upper part of the pool from about 6 miles above Cordova to about 4 miles below.

The examination from the lock was made under normal conditions and was in every sense satisfactory. Unfortunately the work at Maxine was coincident with a sharp rise, from 4 to 6 feet in this part of the river, and was by no means satisfactory. At Prescott Creek the same condition prevailed to a less extent, but we took unusual pains to determine the condition of this locality, putting 3½ days on this single creek and the work here, although hampered by the high stage of water, was fairly satisfactory. When we reached Cordova the water had fallen nearly to normal, and examination of the pool itself, allowing for the effect of the recent fall, was reasonably satisfactory. That of the affluents above backwater was not, as they had been scoured out by the recent rains.

We found it convenient to consider the waters examined under five heads: (1) The pond itself, the main open body of water; (2) the small bights (or bays) of the pond; (3) the bayous at the mouths of creeks and branches;[1] (4) the dead water or backwater of the creeks and branches. This is from the head of the bayou up to the free running water of the creek. It is practically still water, but is all within the creek banks. The bayou is out of the creek banks; (5) live water of creeks and branches where the water is running as freely as before the pond was made. In addition there were marshes, pools, etc., caused by the pond, but outside of it, and similar ones not caused by it.

POOL OF LOCK NO. 12, COOSA RIVER.

JUNE SURVEY.

Physical condition.—The rise of water is about 63 feet and the backwater extends for 25 miles. It was closed in the summer—June or July—of 1914. For the lower 5 or 6 miles up to the Narrows the river runs in a gorge, and the banks of the pond are against the bluff on each side, there being no wide spreading out except in the bayou of Paint Creek. The country adjacent is wild and sparsely

[1] The bayou for any creek is the part of the pond filling the valley of the creek which is deep enough to overflow the former banks of the creek. Bayous and bights differ only in degree, but the latter are usually so much more open to wave action that the breeding conditions may be essentially different.

settled. Above this the land is lower and the pond spreads out widely over low grounds, especially about the old mouths of creeks—Slaughter Creek, Spring Creek, Cedar Creek, etc.

Paint and Waxahatchie Creeks, coming in below the Narrows, and Slaughter, Spring, Peckerwood, Beeswax, and Bullace above the Narrows, are all large creeks, Waxahatchie and Cedar especially so.

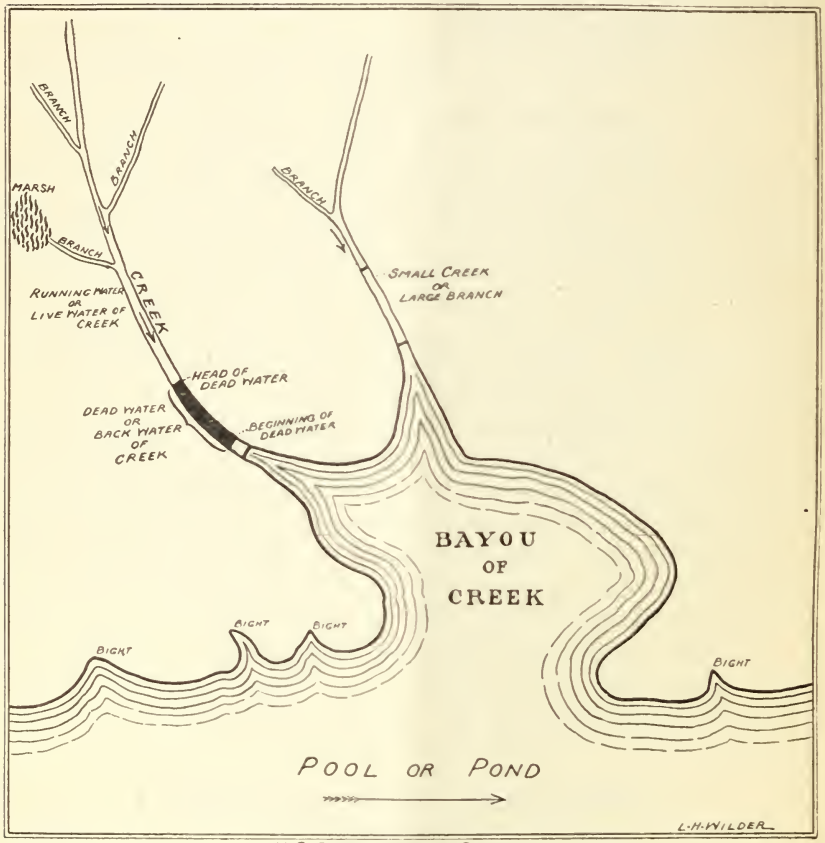

Fig. 1.—Representative creek, bayou, and pond. Pool is the term used by the United States engineers for the water impounded above a lock for navigation. Note that creeks and branches differ only in size.

All except Waxahatchie and Bullace have large bayous covering many acres. Waxahatchie runs in a gorge in the lower part of its course and Bullace is so far from the dam[1] that the water is not raised high enough there to make a large overflowed area.

In spite of the rise of the bed of the normal river, the pond is much wider above the Narrows than below. The country above the

[1] About 20 miles.

Narrows is more level and more thickly settled than below. In places it is a fairly good farming country. There is little stowage of water, it running freely through the weir—and consequently more floating stuff goes past the dam than one would expect in a pond

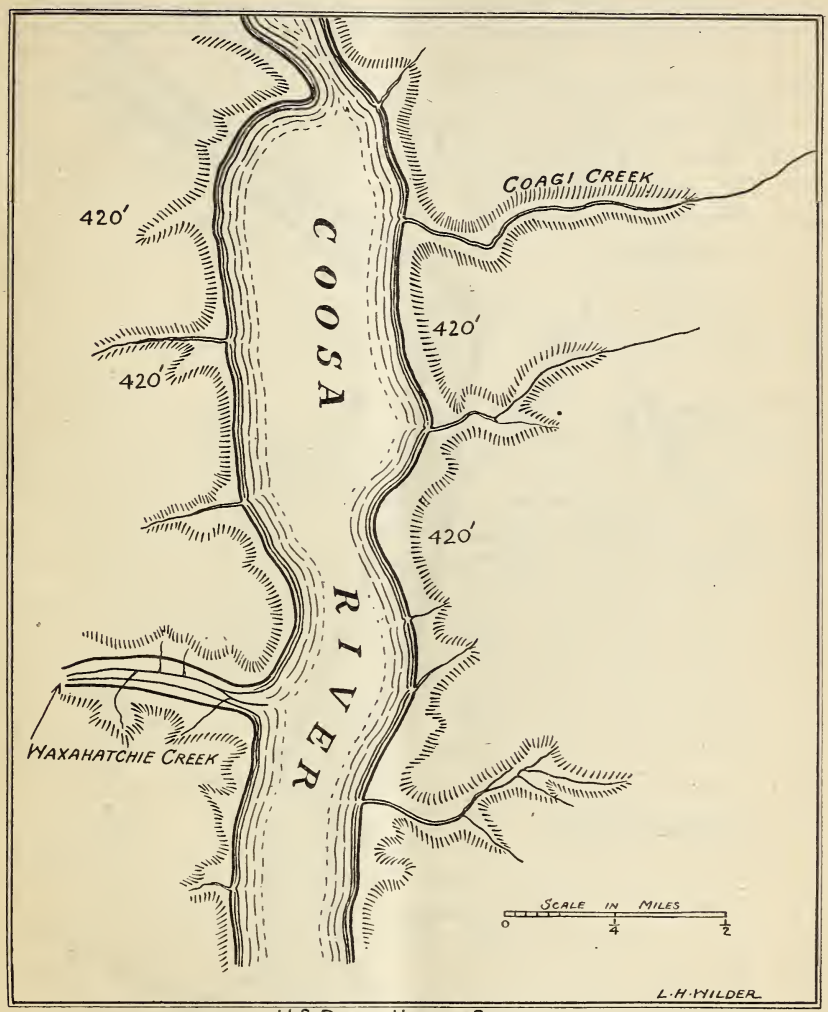

Fig. 2.—Section of pool of Lock No. 12, Coosa River, below the Narrows. Outer hatched line is 420-foot contour. Inner line is old line of Coosa River. The Narrows is about 4 or 5 miles above dam. Elevation of water here is about 59 feet.

of this size. Nearly all of the trees and brush were cut off the pond before the water was turned in. Over some of the areas this material was removed by hauling off or burning, and over others this was not done, or incompletely done.

This is a constant level pool. There is no necessity for its being so, but the impression has got abroad that variation of the water level is productive of malaria, and to prevent this the power company raises the gates whenever a flood is expected and closes them

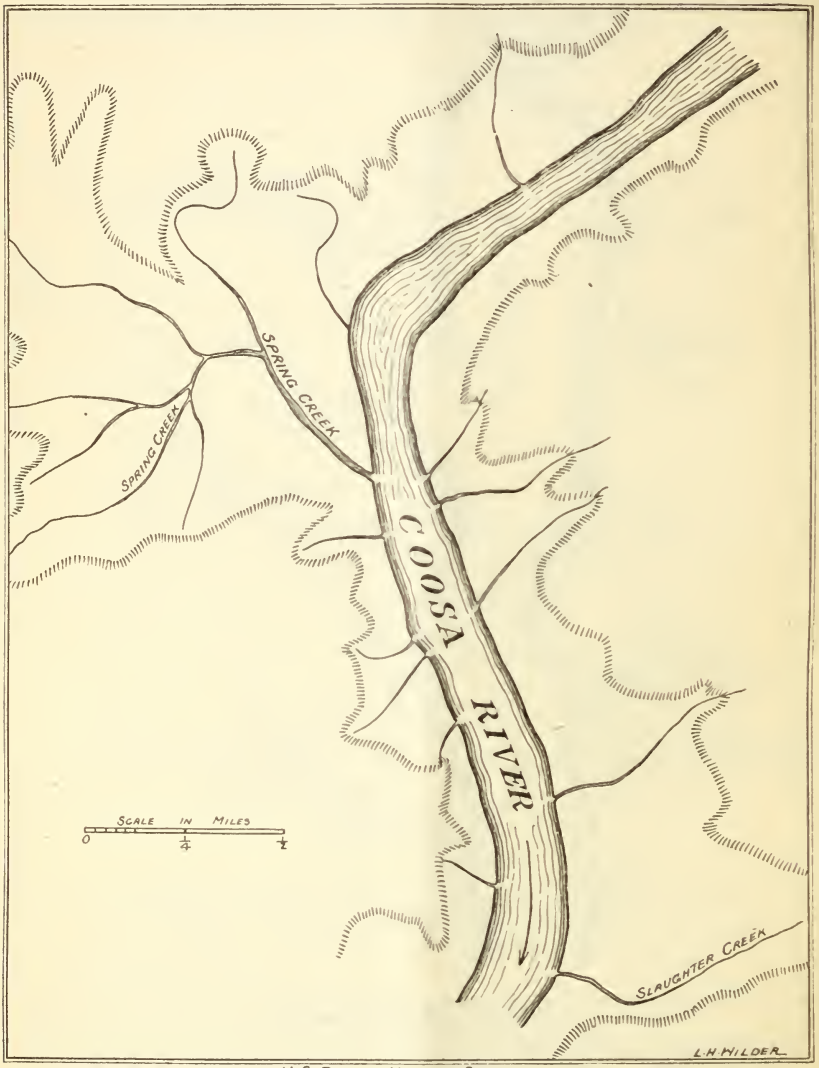

Fig. 3.—Section of pool of Lock No. 12, Coosa River, above the Narrows. Elevation of water a little less than in figure 2, yet section overflowed by pool is greater. Water here is raised about 43 feet, the map covering the area from 7½ to 10 miles above the dam.

when it has passed. As the flow in the river has been in excess of the requirements for power, the company has been able to keep the level very nearly on the 420-foot contour during the summer and

fall. Consequently, there is minimal stranding of drift and floatage due to change of level during this part of the year. Fortunately rises will take place during the rest of the year, and a large quantity of floatage and drift was landed up on the bank during the spring rise.[1]

In spite of this constant level there was only a very small amount of floatage on this pool during the June survey. There were practically no pine needles, which had been so abundant the previous fall, and leaf floatage was absent, except in a few creeks. The cutting out of the trees of the pond has to this extent been an advantage.

A large amount of drift comes down the Coosa, and this, with such logs of the cut trees as were not removed, formed hammocks in some places. It is surprising, however, how few such collections of logs there were.[2]

The water was mainly clear. During the June survey algæ were not present in sufficient quantities to be a factor in the breeding of mosquitoes.

Biological conditions.—The June survey also showed one thing very clearly, viz: The pond furnished few, if any, breeding places of sanitary importance for *Anopheles*. In the body of the pond (including bayous of affluents), they were practically not found. In the backwaters of creeks they were found almost exclusively just below the head of backwater, and in such cases in the running water higher up and in the pools and marshes on the sides of running water they were always breeding, and breeding more freely than in the backwater. The evidence was all in favor of these latter being washed down from above. This was true of Paint, Coagi (very few), Beeswax, and Bullace Creeks. When the running water or the small marshes close to the sides of the creeks were not breeding, larvæ in numbers to be of sanitary importance were not found in the creek below it. The great majority of the breeding about the pond at this time was in the live (running) water above pond level and in the marshes adjacent thereto, and that in the pond was almost confined to the affluents about the head of backwater. It must be noted, however, that even if the larvæ found in the backwater of creeks are washed down (as eggs or larvæ) from live water above the pond level, yet the pond should be charged with the production, or a certain proportion of the production, of mosquitoes which takes place there, as a proportion of the larvæ which lodged in this backwater would have been washed further down and drowned had the pond not been in existence. This must be balanced against the production

[1] By drift is meant floating stuff of all sizes. Floatage is small, or very small, floating stuff. (See Reprint, U. S. Public Health Reports, No. 244, p. 8.)

[2] The writers have notes of only three or four of these collections of logs.

which would have normally taken place in the part of the affluent now covered by the pond and not now producing.

Larvæ were observed away from the bank in Cedar Creek on leaves and small trash floating in the water. This was on June 18. Two days before there had been a heavy rain on the upper part of this creek, which is very large and long, and both above backwater and for nearly a mile below its head, larvæ of all sizes were found on this floatage, adrift in the stream, against the bank, or adhering to branches of trees that dipped down into it. The lower part of the backwater of the creek and the bayou below it were free from this floatage, and although careful search was made, only a very few larvæ were found against the bank in the former and none in the latter. In the backwater they were fairly abundant, especially high up, and because of the large area involved, comprised a large number. They were of all sizes.

On June 24 another trip was made to this creek to observe progress. It was practically bare of larvæ below live water either on floatage adrift or on the banks; nor were any found in the bayou below, where we naturally expected them to have been washed out. Their disappearance was ascribed to fish control, as a large number of small fish were seen in this creek on both visits—although on account of its depth and steep banks it is not a favorable place for minnows. Leaf floatage was not common on the affluents of this pond in June, except on Cedar and Waxahatchie Creeks, which are very long streams.

As Cedar Creek was a surprise to us in one way, so Slaughter Creek Bayou was in another. The shore around a part of this bayou was apparently an ideal place for producing mosquitoes, as it was marshy, with a number of small pools—cow tracks mainly—some covered by grass and some exposed to the sun. This was examined twice in June (14–15 and 21). On June 14 and 15 a few small Anopheles larvæ were found—too small to develop. Seven days later—when they should have been good sized—a careful search showed practically none. Many of these pools contained water boatmen, but not all of them. Possibly these small pools were too hot—the temperature of the water is recorded June 21, 9 a. m., as 86° F.; 10.30, as 92° F.; 1 p. m., as 96° and 98° F. The thermometer was shaded (with two hats) from the direct rays of the sun. It was a common bath thermometer and only approximately correct. This place was barren of larvæ at the survey on August 22 and 28, but a few larvæ were found in the bayou offshore in water 8 to 12 inches deep, where live grass hung over into the water. They were not enough to be of any sanitary importance. None was found in the dead grass. There was quite a number of Culex larvæ seen at both examinations.

Conclusions.—Anopheles larvæ during this June survey were abundant in the live water of small streams and in marshes and pools adjacent to them, but were practically not found in the pool, except in the dead water of creeks under conditions which implied that they were washed there from above.

Practically all of the larvæ developing into imagos from this June collection were *A. punctipennis.* Of about 600 Anopheles imagos developed two only—from the Slaughter Creek section—were *A. quadrimaculatus.* The same distribution of species—101 *A. quadrimaculatus* to 1,152 *A. punctipennis*—had been found in the survey of November, 1914. Of these *A. quadrimaculatus* all except 36 were found in one place—Paint Creek Bayou. In the latter part of May some imagos (all female) of this species (*A. quadrimaculatus*), were taken in the guest house at the power plant. A careful search by LePrince and Carter was made for their breeding places. Imagos were developed from every collection of Anopheles larvæ we could find within a mile of this house. All were *punctipennis.* It is always possible to miss a breeding place, but careful search was made[1] and it is thought that possibly these imagos might have hibernated from the previous year, especially as this form was not found developing from larvæ in this section for nearly a month later.

AUGUST AND SEPTEMBER SURVEY.

This survey was begun August 18. A 3 or 4-inch rise of the pool had just occurred. Small as this rise was, it sufficed to strand a great deal of floatage. Where the banks were gently shelving, this was left well above the water and such banks were clean of floatage.

The biological condition differed markedly from what the June survey had shown. As at that time, the live water and side pools and marshes adjacent to it were swarming with *A. punctipennis* practically in pure culture and many more than in June. The pond water, however, showed along with *A. punctipennis* a preponderating proportion of *A. quadrimaculatus.* In some bights, hammocks of drift had lodged. Where fine floatage and algæ were mixed with this, larvæ were found and at times in numbers. Thus in the bayou of Sulphur Creek near Talladega Springs many patches of fine floatage had lodged against brush standing in the water, against logs, etc. On these patches algæ were growing, and larvæ were sheltered in practically all of them. The distribution of these two species of Anopheles can not be better illustrated than by this place. In the live water of the several branches of this stream and in the marshes feeding into them, the larvæ of *A. punctipennis* were swarming. Only in one "pot hole" on a small branch did we find any *A. quad-*

[1] The search lasted for two days and two half days.

rimaculatus above the bayou: 2 *A. quadrimaculatus* out of 28 Anopheles. The "backwater" of the creek was practically barren, and no Anopheles larvæ of any kind were found except at the upper end. The bayou yielded both species, but with *A. quadrimaculatus* heavily predominating.[1] Some bights on the shore line of the pond just above this bayou, in which hammocks had lodged, showed the same picture.[2] In general a somewhat larger proportion of *A. punctipennis* were found in the pool water than at these places, but except in Cedar Creek we practically did not find, in the vicinity of the pond, *A. quadrimaculatus* mosquitoes in live water of streams, in marshes, or in small pools. They were found only in the pond itself and in pools which were of some size, as in a large pool up Spring Creek and a concrete tank at Talladega Springs. Our records show over 1,600 imagos developed during the August and September survey in addition to 600 or 800 *A. punctipennis* sent to the laboratory. These are enough to base a judgment on.

In the upper part of the backwater of Cedar Creek, larvæ were found in leaf drifts. No Anopheles larvæ were found in the lower half mile of backwater and practically none in the bayou of this creek, except on the north side one-quarter mile from the mouth. *A. crucians* were found here in bait holes,[3] as were the other two species.

Factors determining breeding.—The breeding in the pond at this time was decidedly irregular in amount. The factors which seem to have determined the breeding were such as give protection to the larvæ and possibly furnish food for them. They were not found where subject to wave action nor where fish could readily get at them. On the other hand, where a collection of drift in front of a bight protected it from wave action and sheltered a mass of floatage with living algæ in it, they were frequently found. In the pond they were found more often in water over 2 feet deep than in shoal water. Possibly this is because of the presence of fish. They were rarely found except in floatage, usually fine floatage with algæ or leaves; heavy drift did not seem to be sufficient. On the gently sloping edges of the pond they were practically absent. They were much more common against a steep bank, if material to shelter them was lodged a little way from it, as was common in bights with steep banks. The gently sloping edges were free from floatage, since the rise of the water level, small as it was, and wave motion had stranded the floatage ashore.

Why larvæ were so rarely found in the backwater of creeks is unknown. This zone, except the upper part, was usually barren,

[1] Two *A. punctipennis* to 14 *A. quadrimaculatus* is one record: 21 to 120 is another.

[2] *A. punctipennis* 0, *A. quadrimaculatus* 24, is one entry; *A. punctipennis* 2, *A. quadrimaculatus* 60, another; and *A. punctipennis* 8, *A. quadrimaculatus* 64, yet another.

[3] These are holes made by digging for angleworms. They were filled with seepage water.

although *A. punctipennis* might be above in live water and *A. quadrimaculatus* below in the bayou.

The breeding was profuse in patches, but there were large areas without larvæ. Some of these places seemed to be physically well suited for breeding and no reason was apparent why breeding was not taking place. There was more production within a mile of Sulphur Creek bayou than we found in the same area anywhere else. Indeed, in only a few other places, as at the mouth of Coagi Creek bayou, south side, in some bights of the lower Waxahatchie, and in a small place in Cedar Creek bayou were larvæ found in even considerable numbers. We did not go into every bight and creek of the pond, but a fairly close survey was made from Cedar Creek to the dam. There was a large water weed growing on logs, hammocks, etc., and along the edges of the pond, with a big bunch of white roots which reached down into and floated about in the water. Never did we find larvæ among these roots, even when some floatage was adhering to them. The same weed and same absence of larvæ were seen in the two ponds in South Carolina. Larvæ were not found in grass recently dead and rotting. Aquatic vegetation, except algæ, is not a factor in mosquito production in this pond at present. On the contrary, algæ were found to be a prominent factor in the August and September survey. Minnows were not generally abundant in this pond. In some places good schools of them were seen, but they were not common. Yet larvæ were practically absent unless protected by floatage or other cover. Minnows were decidedly more abundant than in 1914.

Species of Anopheles in fall.—As *A. quadrimaculatus* was practically not found in this pond during the survey of October and November, 1914 (except in one place on Paint Creek), nor in the June survey of this year, but was the most common form found there during the survey of August and September, it seemed desirable to see if it again disappeared in advance of *A. punctipennis* in the fall. One of our party (Griffitts) therefore returned to Talladega Springs October 26–30. The weather, however, was reported as having been unusually warm for the season. Dipping Sulphur Creek Bayou, Rock Spring Bight, the Bait Holes, and other places in the pond which had given such a high percentage of *A. quadrimaculatus* (88 per cent), he found:

	Per cent.
A. punctipennis	71
A. quadrimaculatus	19
A. crucians (from "Bait Holes" as before)	10

Evidently the ratio of the species had changed, and the evidence was that this was due to the diminution of the *Anopheles quadrimaculatus.*

Malarial fevers.—Malarial fevers were reported as having been very prevalent in the neighborhood of this pond in 1914, and we saw houses that had been abandoned on this account. The survey in June gave no reason to believe that the pond was a considerable factor in the production of Anopheles mosquitoes, but the second examination did. In some parts of it the breeding was prolific. These, too, were mainly *A. quadrimaculatus*, a well-known malarial vector. The production of a considerable number of this species within the distance of flight from residences might be a decided factor in producing malaria.

We were told about the middle of August that there was less—some said much less—malaria in the country in this vicinity in 1915 than during the previous year. If true, this may have been due, so far as this pond is a factor, to the abandonment of houses in the most unhealthful locations or to a change in the biological condition of the pond. Excepting Sulphur Creek Bayou and its environment, we found breeding of sanitary importance in but few parts of the pond close enough to residences to be a menace to their inmates.[1]

A search for mosquitoes in houses, residences, and outhouses was made at the village of Talladega Springs, Fayetteville, and Shelby, and at the Lock 12 power plant, Kytles Mill, and in a certain number of other houses in the country. The findings were interesting, but do not seem entirely pertinent to this paper. One conclusion reached from them is that *A. quadrimaculatus* from Sulphur Creek Bayou visit residences in greater numbers in the parts of Talladega Springs closest this breeding place. In the other parts of the village not more of this species were found than were found in Shelby, 4 to 5 miles from the pond, or in houses in the country far distant therefrom.

RECOMMENDATIONS.

Although the investigation of impounded waters has not advanced so far that we can make definite recommendations for the prevention or removal of all remediable conditions, yet we felt justified in making to the power company owning the Coosa Pond certain general recommendations to lessen the mosquito production therefrom. These were:

(1) That they keep the level of the water as high as their flowage rights will allow during the season when the pond is not producing *A. quadrimaculatus*—i. e., from about October 1 to June 15 or 30—and lower it for the three summer months.

[1] So far as the year 1915 is concerned it seems proper to say here that the weather in late August and September was ideal for Anopheles production over much of the South and that malarial fevers were unusually prevalent in many sections reported to the writers from Virginia to Georgia, inclusive, and over North Alabama. There had also been much fever in Talladega Springs to the latter part of September. It is doubtful, then, if the section under discussion escaped.

This will (*a*) kill the brush and land vegetation up to the high level, and (*b*) land the floatage and much of the drift on the bank at a level where it will be left when the water falls. Both will help to give clean banks during the breeding season, open to both wave action and fish.

(2) To save the rises that come in the summer as much as possible, so as to give as much variation as possible to the level during this season.

High water will be transitory and low water the rule during this season. There is no chance that it will ever get up to the winter level and stay there long enough for the imago to develop from the egg.[1] The effect of this varying level then will be (*a*) to land such floatage as accumulates in the summer, and (*b*) to render many larvæ more accessible to fish by compelling them to move from their shelters or setting their shelters adrift or stranding them. It is believed that if these measures are carried out the breeding of mosquitoes in the pond will be materially lessened.

Some special measures were also recommended for Sulphur Creek bayou and the bights adjacent, and the authorities were advised to introduce as many mosquito-eating fish as possible, the preference being given to *Fundulus notatus*, *Gambusia affinis*, and the smaller sun fish, especially the first mentioned. For that purpose the authorities were put into communication with the United States Fish Commission.[2]

BLACK WARRIOR, POOL OF LOCK 17.

JUNE-JULY SURVEY.

Physical condition.—This dam raises the water about 63 feet. The pool extends to about 7 miles above Cordova on one fork (58 miles) and about 6 miles above the Maxine mine on the other (11 miles, or 69 miles in all). One creek—Yellow Creek—is navigable.[3] The pool of Lock 17 is thus quite large. There is no interference with its level artificially, as it is for the improvement of navigation, not for power, and the freshets rise normally, raising the pond level, which in low water falls to the level of the top of the dam. It would naturally, then, be higher in winter, spring, and early summer than in the fall and would thus tend to have clean banks at the water's edge in the late summer and fall, unless brush holds the floating stuff away from the bank and prevents its landing.

The dam was closed about the first of the year (Dec. 26, 1914). No clearing or preparation of any kind was made for the site. For

[1] For this about 16 days would be required.

[2] Fish of some kind has been put in, but of what kind we are not informed.

[3] Seven feet of water for 8 miles.

nearly all of the first 20 miles, counting from the dam, the pool lies against high bluffs with steep banks, frequently of sheer rock. Only where ravines and water courses enter are the banks at all sloping. Even the mouths of large creeks give no perceptible width to the pool. The creeks themselves run in gorges. About the fork, however, there is considerable level land overflowed in a broad area at the mouth of Prescott Creek. The bayous of the creeks above the fork, as high as Frog-Ague Creek at Cordova, are frequently broad and cover considerable area.

Naturally in a pool of the character of this one below the fork, there would be little accumulation of drift, except that which came out of a creek and stopped about its mouth. This was what was found. There was, however, a great deal of "leaf floatage." Many of the partly submerged trees were dying, and they dropped their leaves in the water. These gathered in the heads of bayous of creeks and in some bights. There was also about the heads of some bayous a lot of fine floatage, which apparently had been washed down the creeks and floated up from the flooded ground. There was much more floatage of the above kinds than on the Coosa, but far less of heavy drift. There was such drift, however, in Prescott Creek Bayou and in some of the bayous near Cordova.

Biological condition.—The biological condition of that part of the pool next to the dam differed from that found at the Coosa pool. Quite frequently we found complete breeding places for anopheles in the pond about the heads of bayous of branches.[1] Anopheles larvæ were found in leaf floatage, especially among the small leaves of the beech and pine needles, but also in the fine floatage collecting at the heads of some bayous. In some places they were breeding profusely, more so than had been found in any pondwater on the Coosa. Where there was little floatage there were no larvæ, although the converse was not true. The majority of such bayous and bights showed no breeding, or very little. The same was the case along the open bank of the pool. The affluent streams were not breeding heavily in live water. There were two exceptions to this: Big Indian Creek, below the dam, and the headwaters at Hollman's branch, entering above the dam.

Of the 100 larvæ developed here all were *A. punctipennis*, except four *A. quadrimaculatus*. Small fish were very abundant in some places; in many others entirely absent. Apparently they had not had time since the filling of the pool to spread all over it. Indeed, the rarity of shallows, etc., make it a pool not very well fitted for minnows, and the total number seen was not large.

[1] By a complete breeding place is meant a place in which the imago develops from the egg deposited at that place.

The same biological condition doubtless prevailed in the upper reaches of the pond. These, however, were visited during and just after a sharp freshet, and allowance had to be made therefor. About Cordova we found the same collecting of larvæ in fine and leaf floatage which we found below; but we found it in fewer places, probably due to the freshet. In two live-water streams examined, one in the town of Cordova, a large number of larvæ were found.

Only a small number of larvæ were saved from pond water here, and owing to accident, not enough of them hatched out to make a counting. Those from the stream in town were *A. punctipennis*, and 150 were developed up to July 15. At Prescotts Creek bayou larvæ were found attached to fine floatage and leaf floatage anchored to limbs of trees, logs, etc., out in the bayou. Some of them were evidently washed out of the main creek by a heavy rain and flood; others, we believed, developed in situ. The basis for this belief was: (1) The presence of larvæ of all sizes, and (2) their occurrence in places to which it would be impossible for larvæ to wash. Schaudinn is quoted as saying that Anopheles larvæ are not found in water over 1 meter deep. Here (and elsewhere) we found many of them in water over 6 feet deep. The water on this flat, however, was mainly shallow—from a few inches to 3 or 4 feet deep. It covered many acres and the total breeding was large. Larvæ were found only in floatage away from the banks; none was found next to the banks, which were gently sloping and free of floating shelter, although they had grass on them. At this place, up to July 9–14, much of the hatch was *A. quadrimaculatus*. The water here (Prescotts Creek Bayou) was mainly shallow, still, and fairly exposed to the sun. Algæ did not seem to be a factor in breeding anywhere in this pool at this time.

SEPTEMBER AND OCTOBER SURVEYS.

A survey was made close to the dam by Griffitts, September 17 to September 21, inclusive, simply to see if *A. quadrimaculatus* had appeared in the pool, as was the case on the Coosa. The pond was at its lowest, and the water clear at this time. Little floatage was found on the pond; the banks were clean, because the pond had been high and had stranded the floatage on the bank and then fallen.[1] Wherever there was floatage, larvæ were found. Fish were much more abundant than in June.[2] There were very much fewer larvæ in the

[1] Griffitts notes that most of the floatage observed at the survey in June must have sunk, as from its location it could not have been washed away and less was stranded on the bank than was present in June. Leaf floatage, which comprised by far the bulk of what was seen here in June, stays afloat but a short time—days only. The same is true of pine needles. Fine floatage does not sink quickly, and bound together with algæ, it may float a long time.

[2] One identified as *Fundulus notatus* was taken.

pool than there were in June. The same two streams which were breeding in live water in June were still breeding profusely. From the larvæ from these streams only *A. punctipennis* were developed; from those taken in the pond 35 per cent *A. punctipennis* and 65 per cent *A. quadrimaculatus* were developed. It seems, then, that *A. quadrimaculatus* appeared in this pool later than *A. punctipennis*, just as on the Coosa. In certain houses examined 46 *A. quadrimaculatus* were found in three residences, no *A. punctipennis;* while in a vacant schoolhouse there were 6 *A. punctipennis* and 1 *A. quadrimaculatus.*

An examination by Griffitts of a few bayous near Cordova, October 13–15, showed the presence of *A. quadrimaculatus* in small proportion—about 7½ per cent—where none had been found earlier in the season. Only 58 imagos were developed, however, scarcely enough to base a percentage upon. There had been several frosts and it was cold, the water being 65° and 67° F. The September examination was not extensive enough to give data of much value in determining the amount of the production of the pool, nor was it intended for that purpose. The same is true of the visit to Cordova. It was too late to expect to find many *A. quadrimaculatus* larvæ.

MALARIAL FEVERS.

There was a considerable amount of malarial fever in the general neighborhood of this pool, from Cordova to the dam on the west side of the river. It is reported as having been particularly severe opposite the fork of the river on the west side, and is thought by the writers to have been equally prevalent in the Prescott Creek neighborhood on the opposite side of the river. We were informed that there had always been some malaria in this country, but only a moderate amount. No systematic investigation of this matter was made, but there seems no question but that malarial fevers were unusually prevalent in the section named last summer and fall. The same was true in a great many sections of the South—it was a bad malarial year everywhere.

Exactly how much of a factor this pool may have been in producing this condition in its neighborhood is not known. It is to be regretted that the biological examination of the pool and its environments was not sufficient to determine this point, although it throws some light on it. In the few residences examined in which cases of fever had occurred 50 *A. quadrimaculatus* and 2 *A. punctipennis* were found. The two *A. punctipennis* were found on October 15th in cold weather with four *A. quadrimaculatus* in the same room. Larvæ from a nearby breeding place developed 31 *A. punctipennis*, no *A. quadrimaculatus.*

ANOPHELES IN HOUSES.

As always, it was found in these surveys that, having regard to the production and proximity to sources of production, *A. quadrimaculatus* were found in residences in much greater numbers than *A. punctipennis*, while the difference was far less for sheds, pigpens, unoccupied houses, under houses, etc. To give the averages of the species found would be futile unless the distances from the source of production of each species and the extent of production were given.

In a section of one village, Talladega Springs, 10 houses apparently received their mosquitoes from (1) a small branch producing *A. punctipennis* profusely, but no *A. quadrimaculatus*, and (2) a concrete tank yielding about 5 per cent *A. quadrimaculatus*, 95 per cent *A. punctipennis*, and breeding profusely. There were other sources of *A. punctipennis* within a reasonable distance, but none of *A. quadrimaculatus* for four-fifths of a mile. Counting the production of the stream as equal to that of the tank—it was this, at least—the production of the two species close by should be 2½ per cent *A. quadrimaculatus* and 97½ per cent *A. punctipennis*, respectively.

The 10 premises gave:

Anopheles punctipennis:	
In residences	0
Under residences	3
Outbuildings	30
Anopheles quadrimaculatus:	
In residences	24
Under residences	21
Outbuildings	24

The residences then give, inside and under, a ratio of 1 to 15 (3 to 45). That of the production is 40 to 1. In other words, we found about residences 600 times as many *A. quadrimaculatus* as *A. punctipennis* in proportion to production, at *about* the same distance from the source of production.

The examination of 41 premises in the same village, including the above 10, having an occupied residence on each, gives:

Anopheles punctipennis:	
In residences	1
On porches	1
Under residences	19
Outbuildings	61
In walled spring	17
Anopheles quadrimaculatus:	
In residences	43
On porches	4
Under residences	31
Outbuildings	91
In walled spring	1

Numerical comparison is not possible here, as the houses undoubtedly received mosquitoes from a number of breeding places, some producing one species and some the other. They were, however, on the average decidedly closer to places producing *A. punctipennis* than to those producing *A. quadrimaculatus*, and the production of the first was many times greater than that of the second.[1] The houses next to the Sulphur Creek Bayou are not included in this list. They gave much greater numbers of *A. quadrimaculatus.*

Having regard to the production and proximity of source of production, the general fact that *A. quadrimaculatus* is much more often found in residences than *A. punctipennis* has been noted by our party for some time and, it is presumed, by others; but this is the first opportunity we have had for a comparison of this habit of the two species with even approximately definite numerical data. It is less extensive in number of houses (10) and less close in the approximation of the production than one could wish.[2] It should be observed how much oftener *A. punctipennis* were found in outhouses than in residences. We have found this to be always true. In our experience *A. punctipennis* has been found only sparsely in residences in the daytime. Whether they do not enter at night, or enter at night and leave, is a question we hope to answer next year. On it depends whether they are a factor to be seriously reckoned with in the conveyance of malaria, and thus it is a matter of the greatest importance to the sanitarian.

AQUATIC VEGETATION—SURVEY OF POND AT BAY VIEW.

A survey was made of a small pond at Bay View near Birmingham, furnishing water for the Tennessee Coal & Iron Co. This pond, the writers were informed, had not produced mosquitoes to an appreciable extent until the summer of 1915, and its environment had been free from malaria. It was several years old. There was no brush on its banks, and the banks had been cleaned with a hoe in the early summer. The company was anxious to have no malaria among its employees. This year, however, there was considerable malaria in the neighborhood of the pond.

We found a singular condition of affairs. The pond was skirted by an aquatic plant, *Naias flexibiles*,[3] which lay in the water like kelp only far finer and more flexible and as thick as it could well grow. It was close up to the shore and apparently[4] had finished its growth and was dying and decomposing. Dipping from the

[1] Note, too, the reversed proportion at the walled spring.

[2] Very few observations made early last spring and in October *may* tend to show that *A. punctipennis* is more often found in residences in cold weather than in summer, but the observations were too few to be worth recording here.

[3] Hitchcock, Bureau of Plant Industry.

[4] The survey was made on Sept. 22.

shore[1] was practically without result so far as Anopheles larvae were concerned, except in two small places where this grass was green. Here they were found in fair quantity. On examination from a boat we found the outside of this ring of grass—the edge next open water—generally alive and containing Anopheles larvae in abundance. Together with another kind (Culex species), *A. quadrimaculatus* and *A. punctipennis* were developed. There were fish in the pond, but not many.

Another pond of this company with much growth on its edges was examined two days later and was practically not producing.

The effect of dead and decaying green grass on production has been alluded to. In addition to the above instance, in two places on the Coosa pond a slight permanent rise of pond level covered flat fields of grass: One, Japanese clover (*Lespedeza*), and one, some other kind. The grass was about 6 inches high and the water from 18 inches to nothing. The places were about 5 miles apart. In the grass in both places were "bait holes" about a foot deep, where people had dug for angle worms, and in them there was no grass. These were from 18 inches to 3 or 4 feet across. They were of every shape. The grass was dead and decaying. The water had been up previous to the first visit 9 days for one place and 11 for the other; previous to the second visit 19 days. In the grass practically no Anopheles larvæ could be found, while in the bait holes they were abundant. From these bait holes many larvæ of *A. crucians* were obtained. Two instances of larvæ killed by leaving grass in the bucket with them until it began to decompose occurred. Grass was put in to prevent the larvae from drowning, as is done in carrying them in a boat.

Another plant (*Sparganium americanum*, or burr reed) was found in three ponds in Virginia in the fall. In one pond, the only one properly examined, Anopheles were breeding profusely. This was in October and the catch was practically all *A. punctipennis*. The study of aquatic growth, as implied in the first paper on that subject,[2] may be an important part of the investigation of impounded waters and their effect on malaria.

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[1] Two men for two hours.

[2] Reprint No. 244, Public Health Reports.

SURVEY IN SOUTH CAROLINA.

The ponds examined in South Carolina were those of Parr Shoals and Stevens Creek. Their conditions will be noted only as they differ from those of the ponds already reported on. These ponds came to our notice in February, 1915, when, at the request of the health officer of South Carolina, a physical survey was made of them by Le Prince and Carter. The object of the surveys was to assist the health officer in determining what measures were feasible for the control of the production of malaria. Certain recommendations to this end were made to the health officer in both cases and copies furnished the power companies.

PHYSICAL CONDITIONS.

There were certain peculiarities common to both of these ponds. They were both constant level ponds, the contour of flowage being very close to the lowest allowable limit of the pond. This last was determined by the War Department, which required that the water should pass over the dam. In neither was wave action fully efficient. Stevens Creek was a long, very narrow pond with trees on the banks protecting it from winds and, where broad enough for wave action to be efficient, was extended in woods and brush. Only in the lower quarter was wave action efficient. The Parr pond was broad enough, but the existence of wooded islands—some submerged and some not—an old railroad embankment, and much large timber and smaller growth partly submerged, as well as wide expanses of shallow water, reduced the effect of wave action over much of its bank to a minimum. In some places it was good. Both contained many partially submerged woods and fields of saplings—pine and hard wood. These were dead or about to die, and as they died would rot and fall into the water, making drift and floatage. In both large collections of drift existed anchored away from the bank.[1] On one of them, in Stevens Creek, a man could walk about. Weeds were growing on them and in them mosquito larvæ might develop. In all these things they were alike—the conditions being intensified in Stevens Creek. In one thing they differed. Minnows were fairly abundant in the Parr pond, especially Gambusia, but were rare in Stevens Creek. Both were full of carp. Also such freshet rises as occurred made

[1] These are called "hammocks" in this county; also "floating islands."

more difference in the elevation of the pond of Stevens Creek than of the other, which also brought down a larger quantity of drift. Both ponds were closed in May or June of 1914, and both were surrounded by a fairly level rich farming country, thickly settled. That of Stevens Creek was the better country of the two. The rise of water in each case was 35 feet. The length of Stevens Creek pond is about 8 or 9 miles, that of Parr 12 to 15. The banks of the original streams came out of the water in the first about 5 miles from the dam, and in the second about 6½ miles from it, leaving rather large flats behind them covered with shallow water, especially at Parr.

The work recommended after the February survey for the pond at Parr contemplated cutting the brush from the banks from high-water line to as low a line as possible, raking the drift and floatage up from the water's edge; breaking up and setting adrift the hammocks and floating islands lodged in the woods; and some other minor work. An attempt to regulate the level of the pond so as to vary it from time to time and especially to keep it high in the winter was urged. The recommendations for Stevens Creek were somewhat different, but as they were not carried out, need not be mentioned. The recommendations at Parr were quite well carried out. The whole of the bank and edges were gone over, the brush was cut out, and the edges were raked. The side pools that needed it were ditched, giving fish access to them. A certain amount of this work was unnecessary, as it was done at places too far from residences to be needed and at places where breeding would not have occurred anyway, and the same amount of work would have been better applied if certain dangerous places needing it had been gone over more often or more thoroughly. On the whole, however, this work was well done and unquestionably lessened mosquito production. Occasion was taken during the biological survey to go with the man who had this work in charge and to show him just what was needed.

The surveys were made from July 17 to August 16. The physical surveys had been made in February, and the fact that we were familiar with the general lay of the problems saved some time on the biological survey.

SHELTER FOR LARVÆ AND BREEDING IN THE PONDS.

Leaf floatage was very little of a problem at Parr. Only in two creeks, Cannons and Hellers, was it sheltering larvæ of any sanitary importance. In another year it will be negligible. This is not so on Stevens Creek. On account of its narrowness, the trees on its banks, and its length, leaves will be abundant for years, and we found

enough larvæ on them to be of sanitary importance. As elsewhere, the fine floatage lodged with drift was the main shelter of larvæ. Algæ were a slight factor in their production at the time of the survey, and doubtless a greater factor later in the season.

This fine floatage consisted to a large extent of a small round granule,[1] apparently the excrement of small worms, mixed with detritus of wood. This material lodged against drift and, protected from wave action by drift or the contour of the bank, was the most frequent shelter of Anopheles larvæ in the pond. At times there would be only small patches of it, or a thin layer, and at times it would be an inch thick. When thick it was not always easy to see the larvæ, and many devices were used to do so. At times it would be compressed between pieces of drift and even forced up out of the water, sometimes 6 or 8 inches, high and dry. Then, of course, it would contain no larvæ. As in other ponds, larvæ were found most often and most abundantly in tortuous, steep-banked bights. The larvæ were protected from wave action by the shape of the shore, while such bights usually contained drift and floatage, and small fish avoided the deep water close to the banks. Coles and Mayers bights were of this nature, the latter at one time breeding profusely. Sometimes a bight, or even a part of a shore line, would be protected against wave action by heavy drift, and if there was even a small amount of floatage and the bank was steep so that minnows avoided it, larvæ were generally found. There was such a place north of the mouth of Cannons Creek.

Along the old railroad embankment a large number of larvæ were found on two occasions on the west side, but practically none was found on the east. This fact was doubtless due to a southeast wind that usually prevailed. After a heavy squall from the southwest none was found on the west side. This shore was steep and had grass hanging over in the water with a moderate amount of floatage against it.

The banks of the river were much higher than the flat lands just back of them, with the result that from where the banks first showed out of water for 2½ to 3 miles higher up there were large shallow collections of water running behind the banks, in some places crossed by ridges of land and in others opening into the river through creeks and branches. Strange to say, we found no breeding of sanitary importance in these places. Occasionally, a number of larvæ would be found in bulrushes or about the mouths of creeks where drift and floatage had collected, but we did not find these wide sloughs producing. They were alive with minnows. Nor did we find much breeding in the bayous of creeks.[2]

[1] It was best seen with a hand lens.

[2] We dipped both from the banks and from canoes.

On the south side of the bayou of Cannons Creek, beginning about a mile and a half from its mouth, there was a field covered with partly submerged saplings, dying and casting their leaves. In this field, from the beginning to about half a mile higher up the creek, this leaf floatage sheltered many larvæ. Larvæ were found all along this creek, from above this place to live water. In the live water and in sloughs, small marshes, and "potholes" adjacent to it, Anopheles were breeding profusely. Many evidently were washing down the creek, but the lower groups were of all ages and too far from live water to have been washed down. They were evidently from eggs deposited about where we found them.

Practically nothing was found on the banks of the bayou of this creek;[1] nor was anything found in its lower reaches (1¼ to 1½ miles from the river). Two visits were paid to this place, July 28–29 and August 13, and while the breeding was not quite the same the second time, the absence of breeding was the same.

Although many creeks were examined, practically no creek bayou except Hellers was found breeding. A small number was found half way up Terrible Creek, and there were enough to be of sanitary importance in a limited area against a steep bank on Coles Creek bayou, but generally the above statement was true.

Hellers Creek bayou covers as much area as some ponds, though less than Cannons. It is continuous on the north with a long extension of shoal water, running about 2 miles up the river behind the bank. This slough was free from larvæ, except in a rather extensive fringe of bulrushes next to the river. It was alive with minnows. The bayou, however, was producing mosquitoes sparsely or moderately for a space of about half a mile on the south side, in fine floatage and drift, and to a lesser extent in leaf floatage lodged against trees, logs, etc., or just adrift. The shallow bank, fairly clean, was not breeding them, or breeding so little as to be of no sanitary importance. It was lined with minnows, many of which were Gambusia. This breeding of mosquitoes covered two areas: The first about 300 yards long and, after a space which was barren, one of about 200 more. Its total production, therefore, was large. This was in flooded woods.

SILVER-LEAF GRASS.

In the upper part of Hellers Creek bayou and in the part to the north of the creek we found very few larvæ; but in a bight above a bridge which crosses the creek we found a mass of water grass in which mosquito larvæ were breeding profusely. They were of three kinds, including Anopheles *quadrimaculatus*. This plant covered a large area (one-half acre or more). It grew with its leaves flat on

[1] Those spoken of above were away from the bank—300 to 400 yards or more.

the water and looked like a bright green lawn. It was growing in from 4 to 8 feet of water; but the water was not visible. Fish were around the edge and some in the mass of leaves, but not many, for they evidently could not penetrate the growth. The breeding of Anopheles would be called only moderate, but that of others was very profuse. Anopheles were most abundant where the leaves were not very thick. The others were everywhere. The Anopheles developed were *A. quadrimaculatus*. Owing to an accident all the pupæ captured, except the Anopheles, died. Later Dr. Howard reported specimens sent him as *Uranotaenia Sapphirinas* and *Culex* of undetermined species.[1] Since this pond was only 14 months old, evidently this grass is of very rapid growth. I have seen it in one other pond, a lake at Columbus, Ga., where it covered the whole surface of the lake—some 6 to 8 acres. It is then capable of doing an immense amount of harm in increasing the propagation of mosquitoes. Two tufts were seen lower down in the same pond and one had been seen near Dawkins—some 3 miles above on the other side of the river. This plant was identified by Dr. Hitchcock, of the Bureau of Plant Industry, as *Hydrochloa carolinensis*. It is known locally as Silver Leaf, but is rare. Only one person in the neighborhood was encountered who had ever seen it. He said that it had destroyed a fishpond. It encourages profuse breeding of mosquitoes. We had this patch raked out and the other three as well, with directions to visit the place once every two weeks and rake out everything that appeared. The three small ones could be destroyed by one operation—the large one could not. This is given in detail, because (1) it is the first time a particular aquatic growth has been a serious problem and (2) this was an exceedingly serious one, and if this grass were to spread as it had begun, an insoluble one. In some older ponds, as we shall see, aquatic vegetation may be quite a problem, but we have seen none so bad as this.

HAMMOCKS IN PONDS.

We found nothing of sanitary importance between the bights above the mouth of Cannon's Creek and the dam. To our surprise we found no breeding of sanitary importance even at Parr Shoals on hammocks and floating islands. True, they had been set adrift before our arrival, but a number of them had not gone far, or others had formed. Some of them were breeding moderately, but nine out of ten were barren. At Stevens Creek we found very scanty production, generally none on the larger hammocks. Where new floatage had lodged against them, it contained larvæ—sometimes

[1] For the identification of this last it was necessary to have the larvæ, and as we had gone to Alabama before we received his letter we were unable to furnish them.

in abundance. Reaching Stevens Creek during a freshet, we found much drift of floatage, which was not the case in the main body at Parr Shoals Pond, where these hammocks were found. The larvæ on a hammock were frequently of different sizes and were sometimes in places to which they could not have drifted, i. e., inside of the hammock, and were, it appeared, from eggs deposited there. It is worth noting that minnows were very common around these hammocks. We found larvæ in them occasionally in water probably 20 to 25 feet deep.

MOVEMENT OF LARVÆ ON THE PONDS.

The freshet at Stevens Creek put in motion a great deal of drift and floatage, which went down stream, and then when the Savannah River, into which the creek empties, rose the floatage stopped and then drifted with the winds. At first the fine stuff and small trash was much scattered, but it was collected together within a few days, and in a few more went to the banks or occasionally lodged against obstructions in the stream. This floatage carried Anopheles larvæ in large numbers. They drifted about across the pond and up and down. At first these were of all sizes, but practically no pupæ; by the end of a week the very small ones had disappeared, the larvæ were nearly all full size and pupæ were present, the latter being more generally found in a resting place than adrift. Full-grown larvæ do not merely drift about on floating objects; they possess considerable power of selection as to where they will go in open water. Griffitts put a full-grown Anopheles larva in the water in Hellers Creek Bayou and followed in a canoe some yards off. It went to a piece of bark. This he submerged slowly, and the larva went off in a fairly straight line for, say, 20 feet and attached itself to a leaf. It left this voluntarily and went about 15 feet at an angle to its former course to another leaf. This was sunk, and so several times. The larva went within 20 minutes at least 90 feet from its starting point over a course of approximately 120 feet. Frequently we would sink a dipper of floatage containing larvæ down under the water to get the larvæ separate. They would swim off—for some feet or yards even—and attach themselves to some object floating on the water. Sometimes they showed distinct preference, passing by bits of drift to attach themselves to other pieces, or letting go one piece to select another. They are by no means, then, entirely dependent on the drift of the object to which they are attached for change of place. When there is any motion on the water, however, we have never seen them leave the object to which they were attached unless frightened.

Over a considerable part of Stevens Creek Pond the breeding was profuse—the heaviest general production we have ever seen in a large

pond. Strange to say, the breeding was sparse, absent for long stretches, at both the upper and lower ends. Possibly the freshet coincident with the beginning of our visit washed out or stranded all the floatage from the upper part of the pond, and with the floatage went the attendant larvæ.

Minnows were scarce in this pond, and yet a shallow place in an old cotton field which showed free breeding one day showed none two days afterwards, and the spaces between the rows had many minnows. This is the only shallow place in any pond where we have ever seen very free breeding. There was some protection from dead grass, but larvæ were quite abundant where there was no protection.

Willows were abundant in the Parr Shoals Pond, and when partially submerged they sent out a mass of fine roots just at or above the water level. These should be ideal shelters for larvæ, but larvæ were very rarely found among them, even when they contained floatage. The same plant with the bunch of white, fibrous, aerial roots hanging down in the water mentioned above occurring in the Coosa Pond was very abundant here, and, as at the Coosa, larvæ were never found among its roots.

This observation at Parr Shoals seems worthy of record, only we have no explanation of it to make. On the evening of August 12 there was a rise of 10 to 12 inches in the lower part of the pond. Much drift came down. There was a steady moderate wind directly up the river, slightly toward the right bank. This had little effect on the heavy stuff, which was deep in the water, but held back the lighter. In the afternoon of August 13 fine drift could be seen in some places like a film on the water. There was little current then—almost none except in midstream. On the 14th there was found a body of very fine floatage, 75 by 150 feet, above the mouth of Cannons Creek in very still water. In this there was a very large number of "baby" larvæ—none over 2 or 2½ days old, most of them just hatched. Whether this patch of floatage was the film seen the day before concentrated, or whether it drifted in already formed, is a question. The larvæ were all of approximately one age and all very young. The floatage itself was out in deep water over the old river bed—about 30 feet deep—but not in midstream. If the floatage had been simply released by the rise of the river from where it was resting with the larvæ already in it, one would have expected them to have been of different ages, as at Stevens Creek. The fact that they were all of one age implies that they were from eggs laid about the same time and very recently when this film of floatage was adrift, i. e., eggs were laid out in the stream. As we left the next morning, the progress of this lot could not be followed. The floatage would naturally, most of it, go to the bank.

SPECIES OF ANOPHELES—PREFERENTIAL BREEDING PLACES.

From larvæ secured in the pond *A. quadrimaculatus* predominated—349 *A. quadrimaculatus* to 42 *A. punctipennis* is the record for the first visit to Parr Shoals. Stevens Creek gave about the same proportion, *A. punctipennis* being rather more numerous. A large amount of breeding was found in running streams and in marshes and pools adjacent to them, but these were not searched as widely as we did later at the Coosa Pool. The record from running streams and from marshes and pools adjacent to them is: *A. quadrimaculatus*, 2; *A. punctipennis*, 280. It is probable enough that these two *A. quadrimaculatus* were accidental contaminations. At Stevens Creek the branches had just been washed out and were not examined. The few developing from this catch—eight only—were *A. punctipennis*. No *A. crucians* were seen at either of these two places, although they were abundant around Hartsville, a town about 40 miles distant.

A thing that impressed us here was that *A. quadrimaculatus* not only was found in the pond but larvæ of this species was not found in the neighborhood of the pond in places where one would naturally expect to find them. It was a fairly flat country and showed a number of small marshes, of little pools of clear water in grass, ditches, potholes, etc., in which one expects to find this species and in which we did find them at Eau Clair, about 20 miles distant. The same thing occurred at the examination of the Coosa pool. Although there were no check examinations there in which we found *A. quadrimaculatus* as at Eau Clair, yet finding this species in considerable number in houses at Shelby—5 or 6 miles from the pond—and in other houses in the country $1\frac{3}{4}$ to $2\frac{1}{2}$ miles distant indicates that they do breed in this section.

Though not extensive, the examination of Pool 17 on the Black Warrior, so far as it went, evidenced the same thing. It looks as if the pond were a *preferential breeding place* for *A. quadrimaculatus*, so that *when a pond is available this species may breed nowhere else;* that places which produced this form before the pond was made do so no longer. If this be true, to determine the influence of the pond on the production in any district of *A. quadrimaculatus*, we must deduct from the production of the pond the number formerly produced by former breeding places *outside* of the pond and now no longer producing, as well as those covered by the pond.

While this hypothesis will explain the facts observed, and hence is an allowable deduction from them, it is not a necessary one. To determine this question, it is proposed that the sites to be occupied by a large pond and its environment be surveyed before the pond is made as well as afterwards. If the site selected be in a district in

which *A. quadrimaculatus* is breeding pretty generally this question can be determined. If after the pond is filled—say, the second year—the differential breeding habits of these two species as to locality are the same as observed at this place and at the Coosa pool, it will be decided in the affirmative. Examination of the surrounding country beyond the possible influence of the pond, to determine the production of *A. quadrimaculatus* therein, should also throw light on the subject. The observations at Eau Clair, not made for this purpose, and at Shelby are on this line. Possibly the presence of the small number (only two) of *A. quadrimaculatus* in the drift in Cedar Creek on the Coosa River may mean that they were from side pools or small marshes very far from the pond and were washed down on floatage. This creek was very large and long and with bold banks, and this could happen.

It is well known how *Aedes calopus* accommodates herself to available breeding places. Remove artificial containers, gutters, etc., and she takes the axils of leaves and other out-of-the-way places. Put out a few buckets of water—"trap breeding places"—and the eggs will be deposited in them to the exclusion of the out-of-the-way and presumably less eligible places. It is then in accordance with analogy that *A. quadrimaculatus* might also show a similar adaptibility.[1]

ANOPHELES IN HOUSES.

The same facts were observed as to the greater frequency of *A. quadrimaculatus* in residences as compared with *A. punctipennis*, as have been given for the Alabama survey, but no attempt was made, as was done there, to get quantitative data.[2]

DISTANCE OF FLIGHT OF A. QUADRIMACULATUS.

Some observations on the distance of flight[3] of *A. quadrimaculatus* were made during this survey. They are not sufficient as yet to publish, but will be used subsequently. Obviously, the breeding conditions which we believe we found existing in the neighborhood of these ponds are ideal for the determination of the distance of flight of this species of Anopheles. If this species breeds only in the pond and

[1] In this connection see "The Mosquitoes of North and Central America and the West Indies," Howard, Dyar, and Knab, p. 221.

[2] We note that at Mr. Cheatham's—about one-half of a mile from the Stevens Creek pond and 100 yards from a stream breeding *A. punctipennis*—68 *A. quadrimaculatus* were counted in one bedroom, and "thorough search not made." No *A. punctipennis* noted. In the same room later "30 *A. quadrimaculatus* taken from wall, larger number on ceiling." No *A. punctipennis* noted. At Mr. Mayers's—about one-fourth mile from the Parr Shoals pond, a bight breeding profusely at the time—"many *A. quadrimaculatus* taken under the house." The house is screened. "No *A. punctipennis* seen at the house," yet there was a place producing the latter species profusely closer than the pond. This comparative scarcity of *A. punctipennis* in residences was, during the summer, observed whenever examination was made.

[3] Ultimate, or maximum, distance of flight is meant.

avoids other suitable places in the vicinity—as we think—it is unnecessary to make the very careful search for local breeding places in the neighborhood of the pond and residence in which *A. quadrimaculatus* is found which is otherwise required, especially if they are found in numbers, as at Cheatham's. One can well imagine that the flight to obtain the first meal of blood required for oviposition may be farther than subsequent ones, which are the only flights which can convey malaria—the impulse to continue the species being greater in most insects than the desire for any special kind of food.

The great flight observed by Le Prince at Gatun was associated with no increase of malaria. The mosquitoes, *A. tarsimaculata*, came a great distance from their breeding place to the nearest sufficient blood supply—the village of Gatun—and fed. They apparently returned to their breeding places—the closest to the blood supply available—to deposit their eggs and did not return. Unquestionably they were not in any considerable numbers in these villages after they became infective to men—about 11 days after feeding for this form in Panama—else there would have been an increase in the malarial rate, which did not vary from three-fourths per cent during this flight and for many weeks afterwards. The flight at Miraflores showed the same picture.

The data we have lead us to believe that the maximum flight of this species (*A. quadrimaculatus*) is farther than has been usually supposed; at least, if the production is very great and no sufficient blood supply is close. In the matter of flight the different species of Anopheles should be considered separately. As they differ in so many characteristics, it would be an unwarrantable assumption that there was for the different species no difference in this. This question—the distance of ultimate flight—not only directly concerns our present problem—the effect of impounded waters on the incidence of malaria—but is very important in all antimosquito measures against malaria.

RECOMMENDATIONS.

Recommendations in detail were made in writing and verbally to the managers of both ponds for their better sanitation as regards malaria. Some of these were being put in force for the pond at Parr before we left.

RELATED PUBLICATIONS.

AVAILABLE REPRINTS OR BULLETINS ON MALARIA ISSUED BY THE PUBLIC HEALTH SERVICE, FROM WHICH COPIES MAY BE OBTAINED WITHOUT COST.

REPRINTS FROM THE PUBLIC HEALTH REPORTS.

28. Prevention and Destruction of Mosquitoes. By Joseph Goldberger. July 17, 1908.
105. Antimalarial Measures for Farmhouses and Plantations. By H. R. Carter. December 6, 1912.
108. Malarial Fevers—Prevalence and Geographic Distribution in Alabama. By R. H. von Ezdorf. December 27, 1912.
156. Malaria in North Carolina. By H. R. Carter. December 19, 1913.
159. Malarial Index Work. Methods used in Obtaining Blood, making Blood Smears and Staining. By R. H. von Ezdorf. December 26, 1913.
160. Malarial Fevers. Prevalence and Geographic Distribution in Arkansas. By R. H. von Ezdorf. January 2, 1914.
170. Prevention of Malaria. Suggestions on How to Screen the Home to Keep out Effectively the Mosquitoes which spread the disease. By R. H. von Ezdorf. February 27, 1914.
172. Malarial fevers. Prevalence and Geographic Distribution in South Carolina, Georgia, and Florida. By R. H. von Ezdorf. March 13, 1914.
175. Quinine Prophylaxis for Malaria. By H. R. Carter. March 27, 1914.
180. Malarial Fevers in the United States. By R. H. von Ezdorf. April 10, 1914.
186. Malarial Fevers. Prevalence and Geographic Distribution in Alabama. By R. H. von Ezdorf. May 1, 1914.
193. Malarial Fevers. Prevalence and Geographic Distribution in Mississippi, 1913. By R. H. von Ezdorf. May 22, 1914.
217. Mosquitoes and Malaria. Report on a Short Trip in Eastern North Carolina. By Ch. Wardell Stiles. September 4, 1914.
244. Impounded Water: Some General Considerations on its Effect on the Prevalence of Malaria. By H. R. Carter. December 25, 1914.
248. Impounded Waters: Their effect on the prevalence of Malaria—Survey at Blewetts Falls. By H. R. Carter. January 1, 1915.
257. Impounded Waters. A Study of Such Waters on the Coosa River in Shelby, Chilton, Talladega, and Coosa Counties, Ala., to Determine the Extent to which They Affect the Production of Anophelines, and of the Particular Conditions which Increase or Decrease their Propagation. By J. A. A. Le Prince. February 12, 1915.
258. Malaria Control. Drainage as an Antimalarial Measure. By J. A. A. Le Prince. February 19, 1915.
260. Control of Malaria. Oiling as an Antimosquito Measure. By J. A. A. Le Prince. February 26, 1915.
272. Anopheline Surveys. Methods of Conduct and Relation to Antimalarial Work. By R. H. von Ezdorf. April 30, 1915.
277. Malaria in the United States. Its Prevalence and Geographic Distribution. By R. H. von Ezdorf. May 28, 1915.
290. Anopheles as a Winter Carrier of Plasamodium. The Mosquito as a Prophylactic Indicator. By M. Bruin Mitzmain. July 16, 1915.

SUPPLEMENTS TO THE PUBLIC HEALTH REPORTS.

11. What the Farmer Can Do to Prevent Malaria. By R. H. von Ezdorf. February 13, 1914.
18. Malaria—Lessons on its Cause and Prevention. (For use in Schools.) By H. R. Carter. July 17, 1914.

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